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HOx MEASUREMENTS IN SONEX WITH THE AIRBORNE TROPOSPHERIC OXIDES SENSOR (ATHOS)

submitted to

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Research objectives

The key link between NO from aircraft exhaust and tropospheric ozone production is the hydroperoxyl radical, HO_2. This link is provided by the reaction, $HO_2+NO \rightarrow OH+NO_2$, followed by the subsequent photolysis of NO_2 and formation of ozone. In the middle and upper troposphere, the production rate of ozone is proportional to the product of the concentrations of NO and HO_2: $P(O_3) = k_{HO2+NO}[HO_2][NO]$. Recent HO_2 measurements suggest that water vapor is not the only HO_x source; convective lifting of acetone and peroxides from the surface can be the dominant HO_x sources in the upper troposphere. As a result, the sources of tropospheric HO_x, and thus tropospheric HO_2, are both larger and more inhomogeneous in space and time than previously thought. To determine the impact of aircraft exhaust on tropospheric ozone, the HO_x sources, HO_x sinks, and exchange reactions between OH and HO_2 must be well understood and characterized for different conditions, such as in the North Atlantic Flight Corridor and downwind of convective storms. This characterization can only be accomplished by measuring OH and HO_2 simultaneously with the meteorology and a suite of related trace species to test the understanding of these processes and to start a climatology of these sources. Making and interpreting high-quality OH and HO_2 measurements from the NASA DC-8 during SONEX is the objective of this research effort.

Summary of Progress and Results

SONEX, which was delayed by aircraft inspection problems, began the second week of October and concluded in mid-November with 16 flights. These flights covered the Pacific Ocean off the western United States, transits across the United States, the western coast of Europe, and the North and Central Atlantic Ocean. Particular attention was paid to the North Atlantic Flight Corridor. ATHOS collected high-quality HO_x data on 15 flights. Observations taken at 5 Hz were typically averaged into 20-second measurements. Each 20-second measurement has precision (1σ) of less than 0.01 pptv. OH measurements were generally made from the surface to flight altitudes. HO_2 measurements, which require reagent NO flow, were made from flight altitudes to near the top of the planetary boundary layer.

On several flights, measurements were made either before sunrise or after sunset. Generally under these conditions, OH was less than 0.005 pptv (less than 10^5 molecules cm^{-3}). These observations provide additional evidence along with the SUCCESS observations that ATHOS has no serious artifacts in the OH measurement.

Measured OH and HO_2 during SONEX was generally lower than the measured OH and HO_2 during SUCCESS (April-May, 1996, central United States). Whereas during SUCCESS midday OH was 0.1-0.5 pptv and HO_2 was 3-15 pptv, during SONEX midday OH was 0.02-0.2 pptv and HO_2 was 0.5-8 pptv. Part of this difference results from the midday solar zenith angles, which were larger during SONEX than during SUCCESS due to both the season and the generally higher latitudes sampled during SONEX. However, some of the difference may be due to differences in HO_x sources, since less air influenced by convection was sampled during SONEX. These possibilities await post-flight calibrations of ATHOS and analysis of observations of HO_x and simultaneously measured meteorology and trace species.

Publications

none